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SPECIAL
REPORT

PRESERVING ALFALFA as LOW-MOISTURE SILAGE

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ABOUT THIS REPORT . . .

This report discusses the research that the Agricultural Research Service, United States Department of Agriculture, is conducting to investigate the feasibility of preserving alfalfa as low-moisture silage.

Low-moisture silage is forage that has been field dried enough to prevent seepage when stored in a conventional upright or bunker silo. Forage similarly dried and preserved in a special, airtight silo is called haylage.

Research results have been promising. Low-moisture silage offers relief from the losses of drying hay in the field for those farms and dairies equipped with conventional but not with airtight silos. It has fewer shortcomings than the direct-cut method of ensiling forage crops, but requires more careful management.

Scientists of the Agricultural Research Service at Beltsville, Md., have consistently produced high-quality forage by this method—forage that compares favorably with any produced by any of the other methods.

Information in this report was provided by the Animal Husbandry Research Division, Agricultural Research Service.

PRESERVING ALFALFA AS LOW-MOISTURE SILAGE

In 1963, more than nine-tenths of the forage produced in this country was grown by farmers, dairymen, and ranchers for their own stock. Thus, the quality of forage fed on a farm usually depends on the owner's technical knowledge and managerial skill—on his awareness of the merits of high-quality forage and on his ability to harvest and preserve his hay crops when their nutrients were at their peak.

High-quality forage is the most economical feed that a dairyman or farmer has. Although energy-rich grain supplements are required for high milk production, good forage alone furnishes all the nutrients, vitamins, and minerals that a dairy cow needs to maintain herself and her milk production at low to moderate levels. Agricultural economists usually agree that a dairyman cannot make the most of his investment without an adequate, economical supply of high-quality forage.

Poor-quality forage may not be worth the time and money taken to feed it. Its returns in growth and production are usually disappointing unless expensive supplementary feeds go with it. It usually costs more per ton to harvest and store than good-quality forage.

Inferior quality may result from rain damage to hay, faulty storage, or harvesting at a late stage of maturity.

Preserving alfalfa as low-moisture (LM) silage appears to be a practical way of attaining high-quality forage. LM means forage that is dried enough in the field to preclude seepage when ensiled in conventional upright or bunker silos, but is too wet to be stored safely as hay. The moisture content of LM forage may vary between 35 and 65 percent. When such forage is stored in special, airtight silos, the product is called haylage.

Research in progress by scientists of the Agricultural Research Service, USDA, at Beltsville, Md., compares LM alfalfa silage, directly or indirectly, with field-dried hay, barn-dried hay, direct-cut silage, and haylage. Results show that preserving alfalfa as LM silage in conventional and bunker silos is practical and probably more economical than any of the other methods, although it requires more careful management.

Because forage cut for hay has to dry longer in the swath than forages cut for LM silage or haylage, it is more vulnerable to rain damage, especially in the Eastern States. This alone has motivated research into other ways of preserving forage.

Direct-cut silage in the experiments was alfalfa harvested, chopped, and ensiled in one continuous operation with no timeouts to permit the alfalfa to wilt. This method of preserving forage is generally unsatisfactory. Critics cite low animal acceptability, heaviness, wetness, and foul odors as some of its shortcomings. Direct-cut silage in many instances is no better than rain-damaged hay.

The haylage in the experiments was alfalfa dried in the field until its moisture content varied between 50 and 60 percent. It was then ensiled in specially designed, airtight silos. Like high-quality LM silage, it has none of the shortcomings of direct-cut silage. Airtight silos, however, may not be available to many farmers and dairymen needing relief from the hazards of haying.

The objective of current ARS research is to investigate the feasibility of using conventional silos to store LM silage. Successfully storing alfalfa and other forage crops as LM silage would extend the use of conventional silos and permit silo owners to realize more from their investments. Many silos now used for corn silage are empty in the spring and summer.

WEIGHT CONSIDERATIONS

If silage is measured in tons of total weight, LM silage will be a disappointment. In terms of dry matter, however, the tons of actual feed may be surprising. A load of direct-cut forage (20 percent dry matter) that weighs 6,000 pounds will contain 1,200 pounds of feed. But a 6,000-pound load of LM forage (50 percent dry matter) contains 3,000 pounds of feed. About 100 tons of direct-cut forage has to go into a silo to store about 20 tons of feed. But 40 tons of LM forage would have the same amount of feed. Moreover, the 100 tons and the 40 tons would occupy about the same amount of space in the silo.

ACHIEVING SUCCESSFUL STORAGE

Air is the enemy of silage. If excessive air is entrapped in the forage during filling or gets in after the silo is closed, spoilage will certainly follow. Spoilage may appear as large areas of mold, dark-brown or charred areas in otherwise good silage, noticeably high temperatures in the silage, or ammonia-like odors.

Storing alfalfa and other forage crops as LM silage is not new. USDA scientists commented upon it favorably in 1930. Farmers in Italy have used a similar method successfully on unchopped forage for centuries—they place weights of 800 to 2,000 pounds on the silage to press out and help keep out destructive air.

Airtight silos became available to American farmers and dairymen in the 1940's. Their use provides excellent preservation of forage and eliminates the inconveniences of the Italian, or Crema, process. However, it was economically important to determine whether some of the advantages of these special silos could be made available to farmers owning only conventional silos. The scientists who initiated this research recognized that excluding air would be an additional problem in regular silos.

Keeping Air Out of Upright Silos

As alfalfa or other forage crops lose their moisture after cutting, they become light and fluffy. Excluding air in the silo becomes increasingly difficult.

In successfully preserving alfalfa as LM silage, ARS scientists took deliberate but not excessive precautions to exclude air. They used tight silos that had tight doors. They harvested the alfalfa at an early stage of maturity when it was more pliable and would pack down more easily than at a later stage when its stems would be stiffer.

They also used a hay crusher or hay conditioner on swathed alfalfa to speed wilting and reduce weather risks. After raking, they chopped the crop as fine as possible so it would pack well in the silo. The chopper was set at ¼ to ⅜ inch theoretical cut. The knives were sharp, and the shear plate was in good condition.

The silos were filled rapidly with some variations in distributing and tramping the forage. When filled, they were capped with a layer of direct-cut alfalfa, and the cap covered with weighted plastic.

No improvement in preservation could be attributed to the use of high-moisture plugs after each day's filling, or to the use of rubber door gaskets.

Spoilage was associated with the lack of distribution and tramping during filling. High recoveries resulted from silos filled with the help of a mechanical distributor. Although the use of mechanical distributors is desirable, occasionally distributing the forage by hand and tramping it are also satisfactory.

The rather small amount of spoilage occurred mostly on top layers of silage. Spoilage that occurred in lower sections of one silo was associated with forage that remained on the wagon overnight.

Temperatures taken during storage at various levels in the silos ranged between 87° and 112° F. during the first week or so of storage but then gradually declined. An absence of temperature differences at different locations within the silos indicates effective exclusion of air.

Keeping Air Out of Bunker Silos

Storing LM forage in bunker silos should be considered more hazardous than using upright silos. Bunkers have the geometric disadvantage of a large surface compared to storage capacity. Nonetheless, the scientists at Beltsville completely overcame this disadvantage by careful management. In 2 years' experimenting, they recovered 87.4 and 90.6 percent of the dry matter stored, about the same as in conventional, upright silos. The alfalfa crop was harvested and processed in the field the same as crops destined for upright silos.

The first year the bunker was filled with an elevator—to see if this method promoted even distribution of the forage and facilitated continuous packing with a wheel tractor. Each bunker wall was lined with a sheet of 4-mil plastic 20 feet wide. The excess was placed across the silage surface when filling was complete. The scientists then placed other plastic sheeting over this partial covering and weighted it down with sawdust. This procedure completely enveloped the side and top surface of the silage.

The second year, the scientists utilized the drive-through-and-dump method to fill the silo. A wheel tractor was used to pack the silage. The sealing involved the following: A 10-foot-wide sheet of plastic lined one bunker wall and the excess was folded under the top seal. An 8-foot-wide sheet lined the other wall and the excess was laid over the top seal. A 4-mil sheet of the same plastic became the top seal and covered the entire surface. Still another sheet of a different type of plastic provided a double seal on half the surface on one end of the silo. Finally, a layer of sawdust weighted all this down.

There was no advantage in loading the bunker with an elevator.

Nor was there any advantage in using a double layer of sealing film rather than a single one.

Spoilage occurred almost entirely at the surface in a band next to the silo wall. But less occurred when the top edge of the side-wall liner was folded under the top seal. Spoilage during the second year would undoubtedly have been less if both edges of the silo had been treated in this manner—nearly all the spoilage occurred along the side where the side liner was folded on top of the surface seal.

During the second year, gas losses decreased, going from the top to bottom layers in the silo. These losses were associated with exposure during storage rather than to exposure during the feeding-out period, when all layers received about the same amount of exposure.

Temperatures taken during storage were uniform and indicated that the silage was sealed well at all levels.

LM SILAGE VS. HAY

Curing in the field is the traditional way of making hay. The crop is mowed and then lies in the swath or windrow until it is dry enough (approximately 25 percent moisture content) to store without molding and spoiling. Drying promotes safe storage. It also promotes leaf shatter, and the leaf portion of alfalfa and other crops is higher in feeding value than the stems.

ARS scientists found that under good conditions, field drying of hay is a relatively efficient way to preserve crop nutrients. Dry-matter and nutrient losses average 21 percent between the standing and the fed crop.

Under unfavorable conditions, however, field losses mount swiftly. A single rain may result in losses of as much as 37 percent of the total crop dry matter, and add further labor cost for reraking and redrying. Losses of 100 percent are possible. In humid regions, possibilities easily become probabilities. Good field curing of heavy crops frequently requires 3 good days in a row in humid regions. The odds of getting such a period during May and June are not very good. The practice of waiting for a forecast of good weather sometimes avoids rain damage but may result in crops that are too mature.

Alfalfa cut for barn drying needs about 1½ good days of field drying. This method narrows the odds in favor of the haymaker, but the hay still has to dry further in the barn. Barn drying hay with heat costs between $3 and $12 per ton, depending on how many tons are dried.

In contrast to the 1½ to 3 days needed for hay, alfalfa and other crops cut for LM silage may be in the silo within 24 hours after cutting. This brief exposure markedly reduces the possibility of rain damage.

Preservation of Nutrients

Storing alfalfa and other forage crops as LM silage impressively preserves the crop's nutrients. In several years of experimentation, ARS scientists have consistently recovered about 90 percent of the dry matter stored. This dry matter has shown a consistent tendency for higher crude protein and lower crude fiber than matched hay made from the same crop.

Chemical evaluation of this silage showed a low acidity, which could be considered indicative of poor quality. But other chemical characteristics refuted this assumption. Ammoniacal nitrogen values and those for butyric, propionic, and acetic acids were low; lactic acid values ranged from 2.2 percent to 7.5 percent. In all ARS silage experiments, highest animal acceptability has consistently been observed along with low values for ammoniacal nitrogen and acetic, propionic, and butyric acid.

These relationships indicate limited carbohydrate fermentation and well-preserved protein. Apparently, the limited fermentation of LM silage reflects the absence of undesirable changes rather than the presence of desirable ones.

The silage had a mild, pleasant aroma.

The carotene values of 40 to 50 micrograms per gram of dry matter are low for silage but higher than those typical of good hay. Although this lowering of carotene value appears to be typical of LM silage, the values are still more than adequate for cattle.

Feeding Trials

During two consecutive winters, ARS scientists at Beltsville compared the feeding qualities of this LM silage and heat-dried hay made from the same crops of alfalfa. The silage proved to be the equal of hay. The cows fed silage ate as much and produced as much as cows on hay.

The first test lasted 120 days and involved six milking cows. The forages were fed twice daily to individual cows, and forage refused at each feeding was weighed back.

Test results showed that the cows ate an average of 24.3 pounds of silage dry matter each day against an average of 23.0 pounds of hay dry matter each day. The cows on silage averaged 23.4 pounds of milk each day against 22.5 for the ones on hay. None of these differences were statistically significant. All cows made small weight gains on both forages, but again the differences were not statistically significant.

The second test was run under similar conditions except that 12 cows were used for 105 days. In this test, the cows on silage ate an average of 23.6 pounds of dry matter a day and the ones on hay ate an average of 25.1 pounds of dry matter a day. Milk production averaged 33.5 pounds a day for silage and 32.8 pounds a day for hay. Weight gains were 0.05 pound per day for silage and 0.45 pound per day for hay. None of the differences are statistically significant.

Heifer growth trials during the same periods showed no significant differences between the same forages used in the first milking-cow trials. During the second trials with heifers, U.S. No. 1 hay especially purchased was used instead of the barn-dried hay. Again there were no statistically significant differences between the rates of gain for the hay and for the silage, although intake and liveweight gains were generally lower during the first trial than during the second.

In the first trial, five Holstein heifers ate an average of 16.5 pounds of silage dry matter a day and gained an average of 0.93 pounds each day; for hay, the respective figures were 17.1 and 0.71. In the second trial, six Holstein heifers ate an average of 21.3 pounds of silage dry matter a day and gained an average 1.71 pounds a day; for hay, the respective figures were 21.5 and 1.62.

The trials ran continuously for 90 and 120 days, respectively.

Digestibility Trials

For further comparison of LM silage and hay, the scientists conducted digestibility trials with sheep. In the first trial with six animals, the silage was significantly more digestible than the corresponding hay; but in the second trial, with eight animals, no significant difference appeared. Digestibility of silage ranged from 62.9 to 64.8 percent; for hay the corresponding figures were 54.1 to 66.0 percent.

Other Evaluations

Since LM silage can equal high-quality hay in feeding value, a choice between the two should rest on other factors—speed of harvest, weather hazards, labor and machinery required for storage and feeding, the possibility of total crop losses, and the availability of storage structures. Haying, as usually practiced, is more subject to weather hazards and is seldom mechanized to the same extent as a silage system. Hay cannot be safely stored unless its moisture content is far below that at which LM silage can be safely stored.

Although the ARS scientists produced this high-quality silage by methods easily duplicated on many farms, the silage characteristics observed cannot be automatically achieved—they depend on the crop and on careful management.

The silages had a lower percentage of crude fiber and a higher percentage of crude protein than the hay, apparently because the alfalfa ensiled lost fewer leaves than the alfalfa made into hay. Although the hay was taken in before it was fully dry, shattering losses tend to increase rapidly when moisture levels of cut alfalfa fall below 50 percent. But such losses are variable and could be more or less under other conditions.

ARS research has not definitely established how much moisture a good LM silage should contain. Since the experimental silages with 50 to 57 percent moisture were equal in feeding value to high-quality hay, it appears that this is close to the optimum moisture content. Striving for LM silage with appreciably less than 50 percent moisture would only increase field exposure of the swathed forage and invite field and storage losses.

ARS scientists also point out that harvesting and storing alfalfa as LM silage can be a continuous operation if mowing begins and is maintained a fixed interval ahead of the other operations. The interval may be as long as 1 day. When alfalfa is continuously harvested for LM silage, individual loads may contain as much as 65 percent moisture or as little as 35 percent. Such variations are not serious as long as the overall moisture content of the forage averages about 50 percent.

LM SILAGE VS. DIRECT-CUT SILAGE

Attempting to preserve alfalfa and other forages as direct-cut silage is remarkably simple. The forage is merely cut and then placed in the silo with no time out for wilting or other processing. Since the forage retains most of its moisture, it weighs more per unit of volume than wilted alfalfa and packs down more easily in the silo. Air exclusion is relatively easy. Spoilage losses are practically nil.

But the weight of the silage gradually presses out the moisture, much of which seeps away carrying valuable nutrients with it. The high moisture content also seems to support unfavorable fermentation and additional nutrients are lost in escaping gases. Total losses may be as high as 25 percent of the dry matter initially stored.

Chemical Evaluation

Chemical analyses of direct-cut silage consistently show high values as compared with LM silage for ammoniacal nitrogen, butyric, propionic, and acetic acids. The high values indicate extensive fermentation that further manifests itself in persistent, disagreeable odors.

Chemical additives have been used more or less successfully to diminish odors and improve animal consumption. The additives, however, have practically no nutrients and mostly represent an added operation and an added expense.

Feeding Trials

Before developing the LM method of preserving forage, agricultural scientists despaired of ever producing silage that was the equal of good-quality hay. The reason: Milking cows do not eat enough direct-cut silage to maintain themselves and their production, and heifers fed only direct-cut silage make less-than-average weight gains. In one Beltsville experiment, dry cows fed silage containing 22.1 percent dry matter ate 1.23 pounds of dry matter per 100 pounds of body weight; when the silage contained 34.4 percent dry matter, they ate 2.34 pounds of dry matter per 100 pounds of body weight. Milk production and growth almost always parallel intake of dry matter.

Other Characteristics

Agricultural engineers point out that ensiling material containing 80 percent or more moisture may have these additional shortcomings: (1) Acid produced may decompose the concrete in silos and surely will corrode the metal, (2) silo foundations may become saturated and weakened, (3) silos are harder to clean, maintain, and repair than silos filled with LM forage, and (4) direct-cut silages freeze at a higher temperature than LM and form solid chunks.

One manufacturer estimates that a silo filled yearly with high-moisture forage has a life expectancy roughly one-quarter as long as a silo filled yearly with LM forage.

LM SILAGE VS. HAYLAGE

ARS research shows that the farmer or dairyman who successfully stores his alfalfa as LM silage may reasonably expect to feed about 90 percent of its dry matter. If the alfalfa is stored as haylage, a reasonable expectation is 96 percent. If these values are accepted, then a choice between the two systems may be based on the dollar value of the 6-percent saving. Also to be considered are any differences in maintenance and labor costs between the two systems and an airtight silo's flexibility. The flexibility stems from two facts: Small amounts of silage can be fed out of airtight silos on widely separated dates, and small amounts of replacement forage can be ensiled on the same basis. Some airtight silos can be fed out from the bottom, and this may be advantageous in some situations.

Successfully preserved haylage has all the chemical characteristics previously reported for high-quality LM silage. It exhibits low values (when compared with direct-cut silage) for ammoniacal nitrogen and acetic, propionic, and butyric acids. And these are the characteristics associated with pleasant odors and high animal intake.

Despite the flexibility of airtight silos, good management is still essential when filling the silo. Carelessness may lead to air leaks and consequent spoilage of the ensiled forage.

SUMMING UP

LM silage appears to be an advantageous alternate to much of the hay presently being harvested. Haying, as usually practiced, is more dependent on the weather, has more exacting requirements regarding permissible moisture range, and is seldom mechanized to the same extent as a silage system.

LM silage excels direct-cut silage. It has greater animal acceptability, loses less nutrients in storage, has a mild, pleasant aroma, and is not otherwise sloppy and disagreeable to handle. When carefully managed, it can be stored in conventional upright or bunker silos and its merits utilized by those farms not equipped with airtight silos.

LM silage is more difficult to preserve than direct-cut because it weighs less per unit of volume and does not pack down in the silo enough to exclude air unless the silo filling is carefully managed.

Unresolved problems include the effects of feeding LM silage over extended periods and the possibility of making it from forage crops other than alfalfa. Some of the research needed on these matters is presently being carried out at Beltsville.

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